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Acute traumatic aortic rupture: early stent-graft repair☆

M. Lachat[a,*], T. Pfammatter[b], H. Witzke[a], E. Bernard[c], U. Wolfensberger[b], A. Künzli[a], M. Turina[a]

[a]*Clinic for Cardiovascular Surgery, Zurich University Hospital, 100 Rämistrasse, CH-8091 Zurich, Switzerland*
[b]*Department of Radiology, Zurich University Hospital, 100 Rämistrasse, CH-8091 Zurich, Switzerland*
[c]*Institute of cardiovascular anesthesia, Zurich University Hospital, 100 Rämistrasse, CH-8091 Zurich, Switzerland*

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Abstract

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Keywords: Stent-graft; Endovascular; Acute traumatic aortic rupture

1. Introduction

Blunt aortic injury has an extremely high pre-hospital mortality with rates between 80 and 90% [1,2]. Without appropriate treatment 30% of survivors who reach the hospital die within the first 6 h [3]. Although techniques in aortic surgery have improved over the years, morbidity and mortality rates still remain high [4,5]. In traumatic aortic injuries, delaying surgical intervention until recovery of additional life-threatening lesions has occurred, seems to be an advantageous option in the management of stable and non-bleeding lesions [6–8].

With the introduction of the endoluminal aortic stent-grafting, a new strategy was introduced for treatment of aortic pathologies, especially aneurysms. The first encouraging experiences have been published by Parodi et al. in 1991 [9]. Other investigators have reported the efficacy and safety of this less invasive alternative to surgical graft placement [10–12]. More recently, the successful endovascular treatment of subacute and chronic traumatic descending aortic ruptures have been reported [12–16], but only little is known about aortic stent-graft repair performed in an emergency setting [13,14].

The purpose of the present study was to prospectively evaluate the implantation of stent-grafts in the acute phase, in order to avoid emergent open surgery and its high complication rates.

2. Materials and methods

The study was approved by our ethical committee and informed consent was obtained in all the cases, either by the patients themselves or their relatives.

2.1. Patients

Twelve male patients (mean age: 48 ± 14 years) out of a series of 20 patients with traumatic aortic rupture, were

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* Corresponding author. Tel.: +41-1-255-1111; fax: +41-1-255-5715.
E-mail address: mario.lachat@chi.usz.ch (M. Lachat).

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treated by stent-grafting. Over the same period of time a total of 54 thoracic and 283 abdominal aortic endovascular procedures have been performed at our institution.

Of the 12 stent-graft patients, only one presented with a minor and limited thoracic injury (serial rib fractures and lung contusion). The other 11 patients suffered from at least two additional severe lesions, including lung contusion ($n = 9$) and/or serial rib fractures ($n = 11$, bilateral in eight) with reduced respiratory function, cerebral contusion and/or hemorrhagic lesions ($n = 7$) with neurological deficits, laceration of liver ($n = 4$) and/or kidney ($n = 4$) with functional impairment, and extremity (n = 6) and/or pelvic fractures with major hemathoma ($n = 6$). Nine of the twelve patients were classified as ASA IV and presented contraindications for systemic heparinization and/or emergent thoracic vascular surgery.

Mediastinal widening was detected on chest X-ray in all the 12 cases. Diagnosis and feasibility of stent-grafting was assessed by spiral contrast-enhanced CT and trans-esophageal echography in all the patients. Periaortic and/or mediastinal hematoma was detected in nine patients and intramural hematoma in three patients. Morphologic findings of the aortic injury were as follows: intimal tear with localized dissection in seven patients, contained semicircumferential transsection in four patients and contained circular transsection in one patient. In nine/12 cases the lesion was located more than 2 cm below the origin of the left subclavian artery, but in three patients, the neck length was shorter (between 5 and 10 mm; Figs. 1a and 2a).

2.2. Endovascular aortic repair

In our early experience, stent-grafting was only considered after recovery of associated life-threatening lesions ($n = 3$). In that time-period, open surgery was performed in five additional cases. Impressed by the safety and simplicity of the endovascular technique and the advantages of a minimally invasive approach, we decided to extend the indication to all anatomical suitable cases. Since then, nine/12 (75%) pt with acute traumatic aortic rupture have been treated with early stent-grafting.

Stent-grafting was classified in all the 12 cases as acute, according to Kato's classification of traumatic thoracic aortic injuries [15]. The mean post injury time-period before stent-grafting was 5 ± 7 days (median: 1 day), with the procedure being performed within of 24 h in nine patients, at 1 week in one patient and at 3 weeks in two patients.

The endovascular option was considered in all patients with contained rupture and having a proximal neck with a length of normal appearance of greater than 5 mm and a diameter of <36 mm. Stent-grafting was performed after surgical treatment of non-aortic life-threatening lesions in seven patients. Four patients underwent stent-grafting first. The remaining patient did not require any additional surgery. Endovascular aortic repair was performed under local anesthesia ($n = 6$) or general anesthesia ($n = 5$)

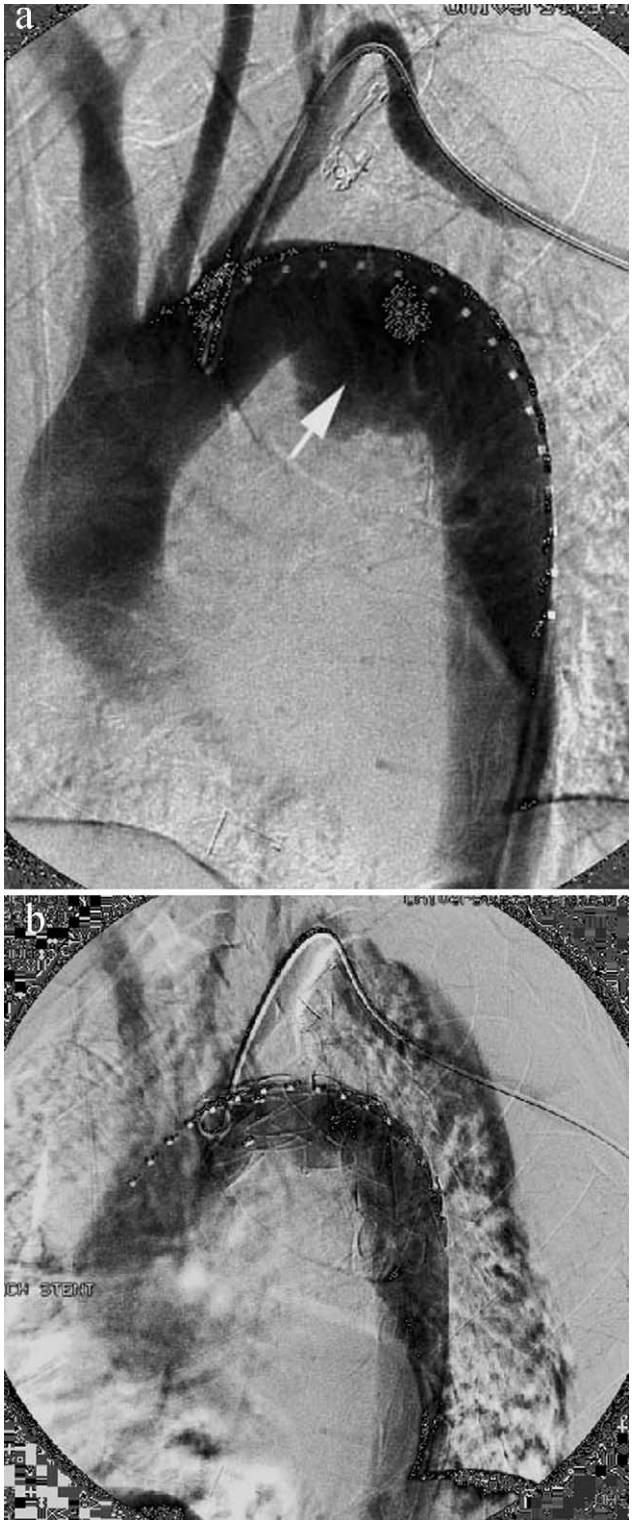

Fig. 1. (a) Intraoperative angiography of traumatic aortic rupture at level of aortic isthmus after blunt chest trauma. The arrow shows the aortic lesion. (b) Angiography at the completion of the endovascular aortic repair (EVAR) by stent-grafting. Despite of a relatively short proximal neck, there is no leakage detectable.

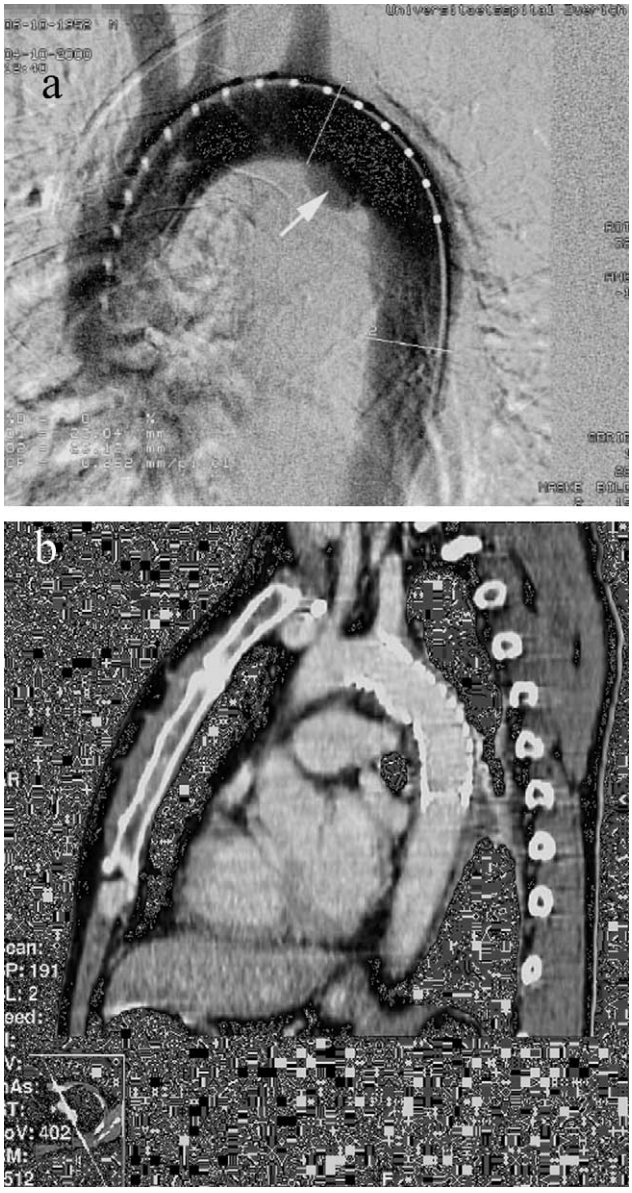

Fig. 2. (a) Intraoperative angiography of traumatic aortic rupture at level of aortic isthmus after blunt chest trauma. The arrow shows the point of aortic rupture. (b) CT scan performed directly after stent-grafting. There is no leak that can be detected. Reconstruction shows a satisfactory proximal anchorage

when patients were already intubated, or when retroperitoneal access was mandatory ($n = 1$). Depending on the associated lesions and the bleeding risk, no heparin at all ($n = 3$) or a maximal dose of 5000 IE of Heparin was administrated i.v. and completely reversed after stent-graft delivery. Mean heparinization-time was 30 ± 25 min. Fluoroscopy and angiography were used for guidance during the procedure and for confirmation of stent-graft position. In patients with a short proximal neck (Figs. 1a and 2a), a pigtail catheter, introduced percutaneously through the left brachial artery was used to identify the exact origin of the left subclavian artery (Fig. 1b).

2.3. Endovascular stent-grafts

All patients have been treated by implantation of one unique self-expanding stent-graft (Excluder® (Gore & Associates) $n = 9$, Talent™ (Medtronic, Inc.) $n = 2$, Schneider covered Wallstent (Boston Scientific) $= 1$). The diameter and length of the endovascular prostheses was chosen based on contrast enhanced volumetric CT data sets of the aorta and pelvic access arteries allowing multiplanar reconstructions. Stent-grafts were oversized by 10–15%. The mean size of the stent-grafts was 33 ± 5 mm diameter (range 20–36 mm) and 14 ± 5 cm length (range 7–15 mm).

3. Results

The mean procedure time was 96 ± 24 min (median 83 min, range 75–180 min). Immediate technical success rate was 100%, as the aortic lesion could be excluded in all the cases by the stent-graft procedure as intended. The origin of the left subclavian artery was partially overstented in four patients without significant flow restriction and therefore a carotid to subclavian artery bypass was not needed. Median intraoperative blood loss was 350 ml.

Only one patient had a post-procedure complication. The patient with the isolated thoracic injury but semi circumferential rupture developed a severe and intractable hemorrhagic shock and died 12 h postoperatively in the ICU (mortality rate of 8%). Postmortem examination suggested the probable cause to be an undetected incomplete proximal sealing. There was no additional procedure-related postoperative morbidity or mortality. Postoperative CT-scans performed before discharge from hospital showed correct positioning of stent-graft as well as complete sealing of aortic rupture in the 11 survivors. During the mean follow-up of 17 months, no intervention-related morbidity or mortality occurred. During this follow-up period, an uncomplicated endovascular reintervention was necessary in one patient because of material failure (polyurethane fabric).

4. Discussion

Despite advances in surgical and reanimation techniques, surgery for acute aortic rupture is still associated with significant morbidity and high mortality rate up to 30% [1,15]. Extra-corporeal circulation induces a cascade of inflammatory responses, that can have deleterious consequences when amplified by pre-existing injury-mediated inflammatory state. Moreover, the systemic anticoagulation required for the extra-corporeal circulation, even at reduced dose as with heparin-coated systems, is undesirable in traumatic patients with multiple fractures and/or parenchymatous or intra-cerebral lesions. Postoperative complications, including renal, pulmonary, cardiac and neurological complications have been reported with rates up to 50%

[17,18]. Several studies shown that surgical mortality after aortic injury can be significantly reduced when a deliberately delayed surgical repair is performed [6–8,22–24].

The risk of developing a free aortic rupture is estimated to be considerably lower in patients with a stable aortic lesion [7,25]. However, in case of active bleeding, or obstruction of the aortic lumen, immediate treatment has to be provided

The significant lower rates of morbidity and mortality for stent-grafting of sub-acute or chronic aortic lesions demonstrate the benefit and advantage offered by this minimally-invasive technique [5,11,19,20]. With a mortality rate of 8% (one/12 patients), our series suggests that this might also be valid in the acute situation of traumatic rupture of the descending aorta. The origin of the leakage in the one patient that died is not clear (Figs. 1a,b). Also a more proximal placement of the stent-graft was intended in this patient, it was not achieved. As the angiographic control showed a complete exclusion of the lesion, a proximal cuff was not added. The postmortem angiographic examination at autopsy confirmed the unchanged position of the stent-graft. Since the expansion of such nitinol stent is temperature sensitive and minimal at temperatures below 18°C, it is impossible to detect if there was already a proximal leakage. Another possible origin of bleeding could have been residual back-bleeding from the first couple of intercostal arteries and/or bronchial arteries that originates at the level of the isthmus. After this event, a control CT scan was performed in all patients directly after the procedure (Fig. 2b) in order to more accurately detect any low-flow leakages, originating for example from the intercostal arteries.

The incidence of paraplegia after surgical repair of acute thoracic aortic rupture is reported to be up to 8% [21,22] and seems to be correlated with aortic cross-clamping and distal hypoperfusion. With arterio-venous femoro-femoral perfusion, postoperative paraplegia could be significantly reduced. With regards to endovascular treatment critical statements have pronounced a higher risk of spinal cord ischemia due to the elimination of intercostal arteries [11]. The placement of endovascular stent-grafts for the treatment of traumatic aortic ruptures did not seem to increase the risk of paraplegia compared to conventional surgical intervention [15], possibly due to the location of the aortic injury. Up to 70% of traumatic aortic transsection affect the segment of aortic isthmus [2], therefore only a few branches to the spinal cord might be covered by implanted stent-graft. None of the patients in our series of traumatic aortic rupture treated with emergency endovascular treatment, exhibited paraplegia or associated neurological complications occurred. To avoid a steal phenomenon, a carotid to subclavian bypass should be considered when the left subclavian artery has to be overlapped. Moreover, occlusion of the subclavian artery, proximal to the internal mammary artery, might be necessary to avoid an endoleak.

In conclusion acute endovascular treatment of traumatic aortic rupture with stent-graft is feasible and an advantageous alternative to conventional open surgery. It avoids thoracotomy, aortic cross-clamping and the use of extra-corporeal circulation. The main advantages are a shorter procedure time, lower risk and the possibility of using local anaesthesia. If the patient does not suffer from other priority life-threatening injuries, the endovascular repair can be performed at first, thereby eliminating the potential risk of free aortic rupture during surgical treatment and recovery of another traumatic lesions.

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Appendix A. Conference discussion

Dr M. Schepens (*Nieuwegein, The Netherlands*): I would like to ask you a question about the Type III endoleak you showed. Actually there are three devices available, the Talent, the Gore and the AneuRx. Two of them have shown problems: the Gore has shown spine breakages and the AneuRx has been withdrawn for several months yet. So I suppose the Type III was in the Talent, which you used mostly. So that means that actually we should raise a lot of questions about all these devices.

Dr Lachat: Of course, but your supposition is not correct. This was a Corvita like stent graft that is not yet available. So far we did not have any material failure with Talent or Gore prostheses. Of course, material failure is a matter of concern for the long-term results of this treatment. But don't forget that what we want to reduce is the acute mortality of these patients. I think that a redo procedures a long time after the rupture might be at less high risk procedure than surgery primary. So I think it is a deal that we can go on.

Mr J. Pepper (*London, UK*): We have had a very limited experience. But I would like to ask you about the access to the aorta, which can be extremely difficult in elderly patients who may be in that group that you prefer not to operate on, particularly if they have extremely severe respiratory disease, and whether you can actually be involved in such an extensive peripheral vascular reconstruction procedure before you actually get into the aorta that you might be better doing a sternotomy and placing it into the aorta by direct vision. What is your experience with this?

Dr Lachat: I think the first goal is to reduce morbidity and mortality and to have the correct approach. If you think that a peripheral or an infrarenal reconstruction combined with an endovascular prosthesis, because of reoperation, severe lung disease or poor heart function might be better, I think this is a valuable choice.

In a non-emergent, elective patient with a thoracic aneurysm, we had to reconstruct first the one iliac vessel in order to get access to the aorta. This patient developed after this short intervention, which required general anesthesia, a severe pneumonia. So if we had opened him first by a thoracotomy to perform an open graft repair, I am not sure he would be alive now.

Dr A. Haverich (*Hannover, Germany*): I would also like to ask you about the contraindication, because it is also our experience, those patients who are really sick and who we want to have the endovascular repair, the radiologists find a contraindication because of severe iliac atherosclerotic disease or others. So not all of them can be treated.

My first question would be, how many patients in this same interval that this series was produced could not be treated with a stent but had to undergo surgical repair or were refused from intervention?

Dr Lachat: Fortunately in this series we had not to refuse a patient because of an access difficulty, but in the same period of time we have operated on with open surgery in eight patients. I think really the limitation of the technique, if the access vessels are widely open, it is the localization of the lesion. If it is too proximal in the aortic arch, it is not very advantageous to treat it by endoprosthetic implantation because you will have to overstent the subclavian artery, maybe the carotid artery, and to perform a very high risk reconstruction on the cerebrovascular vessels.

Dr Haverich: Have you had a patient who had an open mammary graft to the LAD? Would that be, per se, a contraindication for the intervention?

Dr Lachat: Of course, yes, this is a contraindication. This is a very good point. We lost one elective patient because of inadvertent overstenting of the subclavian artery who had a mammary bypass graft.

Dr Haverich: Is there a multicenter registry, maybe company-based, on the incidence of paraplegia, because it is very difficult to get data on this complication in the endovascular treatment group?

Dr Lachat: This is very difficult, actually, to compare surgery with endovascular prostheses, and endovascular prostheses with endovascular prostheses, because there is no standard to describe the lesion, the lengths and localization of the prostheses, hemodynamics during implantation and the anaesthetic method used. So I am not sure a descriptive company-based register will help. But, I would emphases that, a patent mammary artery will protect against paraplegia when overstenting several intercostal arteries by supplying in a retrograde fashion the spinal artery. A reason more not to overstent the subclavian artery.

Dr L. von Segesser (*Lausanne, Switzerland*): I would like to make a comment with regard to the indication. I personally believe that if you have a partial rupture, stent grafting is a very nice approach because the longitudinal configuration of the aorta is more or less safe. However, if you have a circumferential rupture with a distance in between and two segments which are really separated, I personally believe that the stent grafts are not very reliable because the pull-out force for these devices are not very strong and you can have secondary dislocation even if the procedure initially went smooth.

Dr Lachat: I am of the same opinion that you are. We have had, fortunately, just one patient with a circumferential rupture, but this was far below the subclavian artery origin so that we had a very good neck proximal and this was not a problem. But the same kind of lesion more proximally just at the level of the left subclavian artery or more proximal in the aortic arch cannot be treated by means of endografts. That is absolutely correct.